

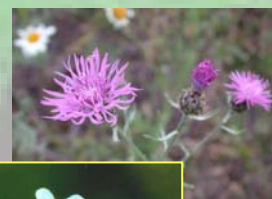
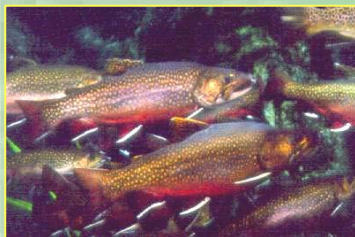


Fourth Annual

WESTERN GREAT LAKES RESEARCH CONFERENCE

March 30-31, 2005

ABSTRACTS



**Northern Michigan University
Marquette, Michigan**



4th Annual
Western Great Lakes Research Conference
March 30-31, 2005



The Western Great Lakes Research Conference provides a forum for information and idea sharing between researchers and managers of national parks and other public lands throughout the Western Great Lakes area.

This conference provides an opportunity for participants to share current research, monitoring, and management issues affecting parks and protected areas.

This conference was collaboratively sponsored and funded by National Park Service and the University of Minnesota. Steering committee members include: **Jerry Belant**, Supervisory Biologist, Pictured Rocks National Lake Shore, **Joy Marburger** National Park Service Great Lakes Research and Education Center, **Bill Route**, National Park Service Great Lakes Inventory & Monitoring Network, **Wendy Smith**, NPS Great Lakes Research and Education Center, **Jerrilyn Thompson**, National Park Service, Great Lakes-Northern Forest CESU, **RaeLynn Jones Loss**, Great Lakes-Northern Forest CESU, University of Minnesota. Thanks to **Jill Leonard**, Northern Michigan University for help with conference logistics.

Conference Sponsors:

Great Lakes Inventory & Monitoring Network

Great Lakes Research and Education Center

NPS Pictured Rocks National Lake Shore

Great Lakes-Northern Forest Cooperative Ecosystem Studies Unit

University of Minnesota

Northern Michigan University

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Northern
Michigan
University

4th Annual Western Great Lakes Research Conference

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ORAL PRESENTATION ABSTRACTS

Community Design to Enhance Appearance and Protect Natural Resources

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Unplanned or poorly planned development can have significant impacts on natural and cultural resources in the western Great Lakes region. Communities want their economies to grow without losing their uniqueness — scenic landscapes, historic downtowns, and places of unique cultural character. “Best Management Practices” and “Smart Growth” concepts have been promoted by community planners and resource managers for the past two decades. However, those tools and techniques have often been slow to reach local decision-makers, citizens, and educators who lack planning or natural resources backgrounds. To facilitate a greater understanding of community planning tools and natural resources management, a group of educators has developed a 65-page guidebook, *Design Guidelines to Enhance Community Appearance and Protect Natural Resources*, which compares traditional development to a more visually appealing approach that also protects natural and cultural resources. Tools to accomplish the recommended approach are suggested.

The guidebook features line drawings and color photos that visually address twenty of the most common development issues, including: shoreline development, water quality and storm water management, landscape character protection, visual corridors, pedestrian accessibility, historic preservation, signage, lighting, parking lot design, building appearance, residential and commercial aesthetics, and cell towers.

The guidebook, along with other educational resources, are being used in classrooms, citizen workshops, teacher professional development, and provided to communities throughout the western Great Lakes region. The *Smart Growth Network* selected the guidebook for inclusion on their *Smart Growth Shareware* CD that is being distributed to 10,000 communities nationwide. For more information: <http://wupcenter.mtu.edu>

Wolves, Moose, and Carcass-derived Soil Nutrients in Isle Royale National Park

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Much is known about the interaction of browsing moose with soil dynamics in Isle Royale National Park (ISRO). However, nutrient releases from moose carcasses in ISRO have not been documented and the influence of wolves on such nutrient pulses through carcass distribution is unknown. We are investigating to what extent predation influences the spatio-temporal distribution of nutrient pulses to the soil from animal carcasses. In spring of 2004 we visited 20 moose carcass sites in ISRO, collecting paired soil samples beneath carcass remains and at control sites beyond the carcass footprint. Preliminary analysis of soils collected from moose carcass sites in ISRO indicates that nitrogen, phosphorus, and potassium sources are elevated, for at least two years, at carcass sites versus control sites. Future work includes investigating potential differences between predated and starvation carcasses. Carcass-derived soil nutrient data will also be combined with carcass location data in a GIS analysis to explore patterns of nutrient subsidies on the landscape and second with kill rate data in a modeling analysis of the annual and historical landscape scale magnitude of carcass derived nutrient subsidies. Our results will improve the understanding of the ecological role of large, terrestrial predators and the links between animal populations and ecosystem processes.

A Summary of Fifteen Years of Breeding Bird Survey Data at Apostle Islands National Lakeshore

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Apostle Islands National Lakeshore, located in northwestern Wisconsin, includes 21 islands and a mainland unit. The islands range in size from 1 to 4,000 ha (3 to 10,000 acres). The park contains a diverse mosaic of habitats that are important for nesting resident birds as well as neotropical migrants.

Apostle Islands NL established a long-term breeding bird survey in 1990 to gain a better understanding of the importance of the archipelago to breeding birds and to identify important nesting habitats. Surveys are conducted annually along 10 transects on seven islands and the mainland unit. Point locations have been permanently marked and are stratified by habitat type.

This paper will present the results of 15 years of monitoring. Comparisons will be made between islands, habitats and years. In addition, trends recorded in the Lakeshore will be compared with state and region-wide trends.

Recent Herp Inventory in the Lake Superior Basin

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Amphibian and reptile inventory and monitoring in the western Great Lakes has progressed substantially in recent years. We review recent work in the Lake Superior basin. A review of the herps of the Lake Superior watershed was completed in 2002

(http://www.fs.fed.us/twcc/docs/amphibians_and_reptiles_of_lake_superior_watershed.pdf).

Over 12,000 herp records were reviewed and a pilot GIS developed. Major recommendations included addressing inventory and monitoring gaps and standardizing methods, improving cooperation among programs, establishing reference sites and a regional herp data center, and addressing conservation concerns, especially wood turtle and amphibian decline, forestry practices, contaminants, disease, malformations, urbanization, global warming, harvesting, and aquaculture. The region supports at least

7 salamander, 12 frog and toad, 6 turtle, 2 lizard, and 10 snake species. Information on reptiles lags far behind that for amphibians in the region. We also review herp inventories progressing in nine national park units in the western Great Lakes. Island distribution matrices were produced for the Apostle Islands National Lakeshore. A nested species analysis suggests that herps colonized these islands during a post-glacial land bridge period, and species assemblages subsequently relaxed after isolation ca. 5000 ybp. Large islands retain more biodiversity than small islands. We performed a pilot wood turtle monitoring study on five major streams in the Ottawa National Forest in 2004, to identify nesting areas suitable for long term monitoring and test methods. We found 52 wood turtles and identified 68 confirmed or probable nesting areas. We recommend 19 areas as primary long term monitoring sites on four major streams, and identify several research and management issues. Results of 2004 herp inventory at Pictured Rocks National Lakeshore and in the Thunder Bay district will also be reviewed.

The Status of Trumpeter Swans (*Cygnus buccinator*) at Seney National Wildlife Refuge (1991-2004): Implications for Future Reintroduction Efforts

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Once an abundant and conspicuous presence in North American wetlands, the Trumpeter Swan (*Cygnus buccinator*) is the largest species of waterfowl native to this continent. However, during the mid to late 1800s market hunting and habitat loss acted in concert to cause the extirpation of this species from much of its historical range. Since then, restoration has focused primarily on re-introduction efforts. From 1991 to 1993, 44 birds were introduced to Seney National Wildlife Refuge (Schoolcraft County, Michigan) in a multi-agency attempt to re-establish breeding populations of this species in the Upper Great Lakes region. To provide information useful to those interested in swan restoration efforts elsewhere, this paper summarizes 14 years of Trumpeter Swan occupancy and productivity. In doing so, we document the first substantial inter-annual decline in swans on the Refuge and provide evidence that suggests birds may just now be dispersing in sizable numbers into other lakes and wetlands in the eastern Upper Peninsula of Michigan. We also present information from which we infer processes regulating swan productivity. In closing, we discuss both the continued need for monitoring and the need for research to examine the effects swans might have on other components of aquatic ecosystems.

Assessing Zn Bioavailability and Diagenesis in a Contaminated Lake System in Illinois

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The sediments of Lake DePue, IL contain elevated concentrations of Zn, Cu, Cd, and As resulting from the operation of a nearby zinc smelter and fertilizer plant for over 80 years. The broad goal of studying this system is to understand the interaction between toxic metals and microorganisms in impacted sediments. The work presented here focused on two aspects: 1) correlating Zn speciation and bioavailable Zn and 2) measuring chemical parameters along a depth profile of the sediments to determine diagenesis of the system.

Zn speciation was probed with X-ray Absorption Spectroscopy (XAS) and voltammetric measurements and bioavailable Zn was measured using a whole-cell bacterial biosensor. Comparing the results of the biosensor with chemical measurements shows that bioavailable Zn does not correlate with the dissolved Zn concentration but rather seems to correlate with certain solid species.

XAS analysis revealed that ZnS predominated near the water-sediment interface but disappeared in the deeper sediments. Because ZnS has a lower solubility than most Zn minerals, we expected ZnS to *increase* with depth. Due to elevated sulfate concentration (10-30 mM) and high sulfate reducing rates measured in earlier studies, we hypothesize that microbial-mediated oxidation of sulfate to sulfide provides a significant quantity of HS⁻ to complex Zn and prevent formation of ZnS in the deeper sediments.

Biogeography of Small Mammals of the Apostle Islands National Lakeshore

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We inventoried small mammals on seven of the 22 Apostle Islands as well as Little Sand Bay in the mainland unit during the summers of 2003 and 2004. On each island and the mainland unit we set baited, Sherman live traps on the ground, in two trapping grids. Trapping grids were either 50m² or 75m², composed of 6 transects of six single trap trapping stations. In addition, we maintained five trapping stations/grid 2m high in trees at the four corners of the grid and in the center. During 3,288 trap nights in 2003 and 1,814 trap nights in 2004, we caught eight small mammal species on the mainland and a subset of those species on seven islands. In 2003 we caught southern red-backed vole (*Clethrionomys gapperi*), North American deer mouse (*Peromyscus maniculatus*), masked shrew (*Sorex cinereus*), and red squirrel (*Tamiasciurus hudsonicus*) on all of the islands except Devil's. In 2004, we trapped mammals in the small, distant (from the mainland) islands nearest to Devils Island and did not capture deermice. Also in 2004 we captured meadow vole (*Microtus pennsylvanicus*) on Basswood Island, a species we did not capture on the mainland unit in 2003. We captured no winter-inactive or winter hibernators, suggesting that small mammals likely disperse to the Apostle Islands in the winter when the water is frozen. Distance to island coupled with island size seems to limit the poorer dispersers, such as North American deer mouse, from many of the islands in the archipelago.

The Great Lakes Regional Collaboration and Executive Order

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The President issued an Executive Order on May 18, 2004 that established the Great Lakes Task Force. The Executive Order recognizes the Great Lakes as a natural resource of national significance and calls for more systematic collaboration and more fully integrated efforts among all departments and agencies with responsibilities in the Great Lakes Basin. The U.S. Environmental Protection Agency was named as lead agency in the Executive Order. Former EPA Administrator Leavitt used the Executive Order to help establish the Great Lakes Regional Collaboration which consists of representatives from federal, state, city, tribal, and congressional interests. This Collaboration is developing a restoration and protection strategy for the Great Lakes that builds on existing plans and will serve as a forum to address near-term regional issues and coordination oversight. The strategy will address eight overarching Great Lakes issues put forward by the Council of Great Lakes Governors. These issues are organized into eight strategy teams by topic: non-point source contamination, persistent bioaccumulative toxics, invasive species, habitat, Areas of Concern restoration, indicators and information, sustainable development, and coastal health. The Collaboration has agreed to allow Great Lakes water diversion issues to be handled by the Annex to the Great Lakes Charter.

Assessing the Impacts of European Earthworm Invasions in Beech Hardwood and Spruce-fir-aspen Boreal Forests of the Western Great Lakes Region

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In the western Great Lakes region, little data exists on the distribution and abundance of earthworm species or their relative impacts to soil structure and plant communities in forest types other than those dominated by sugar maple. The objective of this study was to document the earthworm populations in relation to their proximity to key landscape features (i.e., campgrounds, boat landings, roads, visitor center) for beech dominated forests in Pictured Rocks National Lakeshore, Michigan, and spruce-fir-aspen forests in Voyageurs National Park, Minnesota; and to assess earthworm population relationships with soil characteristics and plant communities. A suite of seven common earthworm species was supported in both forest types with the same species assemblage groups seen in other forests across the Great Lakes region. However, the total earthworm biomass supported by the spruce-fir-aspen forests was half that supported by the beech forest type which was nearly half that reported in sugar maple dominated forests. Landscape features (i.e., distance to roads, trails, campsites, streams and lakeshores) proved to be poor predictors of earthworm biomass and species assemblage. Increasing earthworm diversity and biomass were associated with decreasing thickness of the O_{litter} and O_e horizons, increasing A horizon thickness, and increasing understory plant species richness. In beech forests, changes in plant composition and richness associated with earthworm biomass are most likely related to site conditions that simultaneously affect the biomass and species of worms the stand will support.

Biogeographic Distribution and Genetic Diversity of *Sarracenia purpurea* within the Western Lake Superior Watershed

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Restoring a plant population requires an understanding of 1) how plant morphology is adapted to particular site locations and 2) the inherent genetic diversity and relatedness of populations. To better understand the restoration ecology of *Sarracenia purpurea* L. Sarraceniaceae (the northern pitcher plant) we used demographic and genetic diversity measures to compare populations in the Western Basin of Lake Superior. We measured demographic characters (number of flowers, leaves, fruits) and compared genetic diversity for six populations from Isle Royale National Park, the Keweenaw Peninsula, and Sibley Peninsula, Canada. Analysis of genetic and demographic data showed Canadian populations to be less robust than Isle Royale and Keweenaw populations with smaller population sizes and plant sizes, possibly due to the limestone bedrock underlying Canadian populations, creating less acidic situations. Examination of genetic diversity patterns corresponded with morphological data; Canadian populations are slightly distinct from Keweenaw and Isle Royale populations, which are indistinguishable. The pitcher plant, as a whole, has low genetic diversity and populations across great distances tend to be fairly similar. This indicates that restoration can take place within the Western Basin of Lake Superior using a variety of seed sources, but regional geology may influence observed plant morphology. This study is currently being conducted at Pictured Rocks National Lakeshore and Apostle Islands National Lakeshore.

***Peltigera*, a Genus of Dinitrogen-fixing, Terricolous Lichens: Its Influence on Soil Processes in the Northern Forests of Minnesota**

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Dinitrogen-fixing lichens (cyanolichens) are well-recognized sources of exogenous N, but effects of this input have been little studied. We investigated the earth-dwelling cyanolichen *Peltigera* Willd. in northern Minnesota. Our objectives were to (i) estimate potential N inputs from *Peltigera*; (ii) determine whether available soil N increases near *Peltigera*; and (iii) determine whether decomposition increases near *Peltigera*.

To estimate leached N, we collected leachate from *Peltigera* and non-N₂-fixing lichens for 49 days. To estimate abundance, we surveyed 104 sites, sketched thalli, and determined *Peltigera* cover from digitized sketches. To estimate available N, we buried ion-exchange resin along 150-cm-long transects up- and downslope from *Peltigera* for 110 days. We collected soil along 150-cm-long transects originating at *Peltigera* and along control transects. The soil was laboratory-incubated for 74 weeks and periodically extracted. Soil was also collected 10 and 120 cm from *Peltigera* across northern Minnesota. We analyzed soil for %N and resin and soil extracts for inorganic-N. To examine decomposition, we decayed foliar litter near *Peltigera* vs. moss for 12 months and measured changes in mass and elements.

Estimates of leached and decayed N are small: 232 mg N/ha·yr and 0.1 kg N/ha, respectively, in fire-dependent aspen/birch (where 88% of *Peltigera* occurred). Nevertheless, we found associations of *Peltigera* with significantly increased available N, mineralizable N, %N, and decomposition (p-values<0.05). Moreover, our results suggest a potential zone of influence or "thallosphere" extending 150 cm from *Peltigera*. We encourage researchers and land managers to consider this potential influence when designing ecological studies and management activities.

Bat Inventory and Monitoring at Selected National Parks within the Great Lakes Network

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Lack of information and the recognized importance of temperate bats as key components of Northern Great Lakes ecosystems have placed bats as a high priority for biological inventories at several parks within the Great Lakes Inventory and Monitoring Network (GLKN). In 2003, acoustic sampling and mist netting was conducted at the following parks in the GLKN: Pictured Rocks National Lakeshore (PIRO), Michigan; Apostle Islands National Lakeshore (APIS), Wisconsin; and Grand Portage National Monument (GRPO), Minnesota. Through both methods, six of a probable seven species of bats were verified in all three parks. The only bat not verified was *Pipistrellus subflavus*, a fairly uncommon summer species of the Lake Superior region.

In 2004, further methods were developed at PIRO and APIS to monitor bat activity in habitats of concern to park managers. At PIRO, the lakeshore is buffered by an inland zone consisting of forests managed for sustained-yield timber harvest. Acoustic monitoring was conducted in Forest Inventory and Analysis plots (located both in the lakeshore and inland zones) to examine the effects of differing forest structure on bat species composition and activity. At APIS, seacaves on the mainland and islands provide potential summer bat habitat, however, the extent of use by bats was unknown. To determine relative use of seacave habitat, acoustic monitoring was used to compare bat activity between three habitats (shoreline with seacaves, shoreline without seacaves and inland, open areas) on the mainland, Sand Island and Devils Island.

An Aquatic Synthesis for Great Lakes National Parks: Using Past Efforts to Guide Future Research and Monitoring

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National Parks in the Great Lakes Network (GLKN) are situated in one of the most water-rich locations in the world, and protect diverse aquatic habitats of great ecological value. Because these parks share common environmental and historical contexts and face similar water resource issues, the GLKN and Midwest Regional Office determined that a comprehensive analysis of available aquatic literature was needed. To address this need, we recently completed a wide-ranging synthesis of aquatic research in GLKN parks. Our objectives were to: 1) provide recommendations for aquatic indicators and monitoring strategies; 2) identify common aquatic resource issues and information gaps; and 3) elevate the profile of aquatic information needs in these parks.

Nearly 600 studies were reviewed for the synthesis. Each study was categorized by park and research topic and catalogued in a detailed appendix. Diverse aspects of water resources were addressed in the studies, including water quality, hydrology, groundwater, physical processes, contaminants, and aquatic biota (e.g., fish, plankton, mussels, macroinvertebrates, wildlife, and aquatic vegetation). Fisheries, water quality, and basic limnological studies received the greatest emphasis across parks. We will present a summary of the available information, an analysis of information strengths and needs, and recommendations for future monitoring and research. Overall, we recommend greater attention to Network-wide issues of invasive species, landscape change, climate change, fisheries management and regional policy in the Great Lakes and Upper Mississippi River Basin. Additionally, we identify subsets of parks that share similar aquatic habitats or issues and present opportunities for multi-park research and monitoring.

Coaster Brook Trout in Pictured Rocks National Lakeshore: An Update on the Physiological Ecology of PIRO Coasters

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Coaster brook trout restoration has been ongoing in the waters of Pictured Rocks National Lakeshore (PIRO) since 1997, primarily through the stocking of Tobin Harbor strain juveniles which are derived from the coaster brook trout native to Isle Royale. Beginning in 2001, intensive monitoring of juvenile brook trout movements (wild and stocked) using passive integrated transmitter stationary systems (TIRFID) was begun. Additionally, stocked and wild brook trout have been assessed for physiological changes indicative of differential growth rate and indicators of classical salmonid smoltification. While both these projects are ongoing, initial data suggests that both wild and stocked brook trout move between PIRO tributaries and Lake Superior. Most of these movements are demonstrated by relatively small fish (<200mm), although several fish >300mm (12 inches) have been detected moving during the typical brook trout spawning period. We have also documented differences between resident and stocked fish metabolic physiology (e.g. metabolic enzymes, gill structure) that suggest the potential for enhanced growth in the coaster strain, however, neither strain appears to demonstrate smoltification (at age 1+) as indicated by $\text{Na}^+\text{K}^+\text{ATPase}$ activity. Our data suggests that both wild and stocked brook trout in PIRO make use of the Lake Superior environment; however, we can not yet differentiate between dispersal movements and classical migration. Our data also suggest that there are likely to be differences in strain-specific growth for the fish in PIRO which may be relevant to the expression of coaster behavior.

Vegetation Composition Differences among Ownership Types within Pictured Rocks National Lakeshore

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Pictured Rocks National Lakeshore (PRNL) implemented an intensive forest inventory utilizing United States Forest Service Forest Inventory and Analysis (FIA) program protocols. A 27-factor national FIA sampling grid intensification within PRNL boundaries produced a sampling frame of 1 plot per 90 hectares (n=321). From 2001 to 2004, a total of 148 forested plots within PRNL were established and measured. All overstory, understory, and ground cover vegetation was sampled within 4, 0.1 hectare subplots per plot. Data were analyzed to detect differences in overstory vegetation structure and species composition among federal, state of MI, corporate timberland, and private holdings within PRNL. Parameters investigated include woody species' relative dominance, tree density, stand age, and structural components of the overstory and mid-level canopy.

A Review of Landbird Monitoring Programs in the Great Lakes Network

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Breeding landbird monitoring programs have been initiated on several of the National Park units in the Great Lakes Network. Methodologies and study design vary among the park units, and our objectives were to describe landbird monitoring programs in the Great Lakes Network, conduct a power analysis of existing data, address the adequacy of each park's program and provide methodological suggestions to facilitate regional population assessments. We conducted a power analysis to evaluate the number of years of monitoring required to detect a significant population trend for ten species in three abundance classes (high, moderate, and low). Species in the high abundance class required 8.9 years of monitoring to detect a 10% trend, while the medium and low abundance classes required 13 and 14 years, respectively. All monitoring programs have been in place for over five years, with four parks having >8 years of data on a consistent set of points. All six parks analyzed have sufficient power to detect a 10% annual change in abundance after 10 years, or a 5% change after 15 years for at least some species. Network-wide recommendations include using a standard protocol, data sheet, and database, clearly stating monitoring objectives, reporting results on an annual basis, describing site selection criteria, and other methodological suggestions. We will also present a brief comparison of forest bird population trends from the Great Lakes Network to trends from western Great Lakes national forests.

Holocene Dune Building in the Tahquamenon River Valley, Eastern Upper Michigan

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The origin of stabilized dunes that are abundant within the Tahquamenon River valley in eastern Upper Michigan has proven elusive for almost a century. In the 1930s, Stanard Bergquist attributed these dunes to lake bed deflation upon the rapid fall of glacial Lake Algonquin which had covered the valley prior to ~13,000 cal BP. However, recent optical ages of eolian sand from six upland stabilized dunes suggest dune activity between ~5,500 and 6,700 cal BP. This activity was interpreted as reflecting regional low base level and warmer temperatures associated with the Altithermal. More recently, fourteen optical ages obtained from dunes southwest of Whitefish Point suggest they were emplaced ~10,200-8,500 cal BP along the shore of ancient Lake Minong. Interpretation of this pattern ties dune emplacement with Minong's catastrophic destruction, transitional to modern Lake Superior. Fifteen additional optical ages have now been obtained from dunes that lie as much as 200 km south of Whitefish Point, far inland of Lake Superior within the valley of the Tahquamenon River. This latter set of optical ages spans a time frame that includes both the early Holocene (i.e., ~10,500-8,500 cal BP) and the Altithermal (~7,500-6,000 cal BP). The picture that has emerged from work to date seems to suggest multiple and perhaps interdependent agents of dune building.

Quality Assurance and Quality Control (QAQC) Assessment of Quadrat-based Monitoring of Vegetation at Voyageurs National Park

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Interpreting the results from quadrat-based monitoring of vegetation requires an estimate of the variability associated with it, in order to accurately detect vegetative changes over time. We sampled vegetation to assess one source of sampling error, observer bias, in quadrat sampling at *shorelines*, along *aquatic transects*, and in *peatlands* at VNP, as a part of the park's long-term assessment of "Rule Curve" modification.

To estimate variability among individuals, five or six observers sampled the same vegetation over the same time period. Twenty 1m x 1m quadrats were placed along each of the three habitats, and quadrat frames were kept in the same location during the duration of sampling and observed by multiple individuals. We also tested for differences in field experience by breaking the observers into 2 groups, experienced wetland assessors and newly trained assessors. All observers received 2-3 days of instruction and calibrating prior to sampling.

Along the shoreline quadrats, the more experienced observers noted more taxa and agreed on 8 of the 10 most abundant taxa. The recently trained observers agreed with the more experienced observers on the top three most abundant taxa, but among themselves only on 6 of the top ten. At the peatland site mean richness and mean cover/m² varied less between observer groups. Observer bias was greatest in the aquatic transects. Mean quadrat richness ranged from 4.9 to 9.2 taxa/m² and mean estimated cover ranged between 51.0% and 80.3%.

These results suggest observer bias differs across habitat type, and is greatest for aquatic transects. It also suggests that *relative cover* among differing plant guilds may be the best metric to monitor change over time.

Biology and Management of Canada Lynx in Minnesota

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The Canada lynx (*Lynx canadensis*) is listed as a threatened species under the Endangered Species Act in the United States. Knowledge about distribution, habitat requirements, abundance, and long-term persistence is required for the conservation of Canada lynx in the Great Lakes region. Management is challenging because northeastern Minnesota represents the southern edge of Canada lynx range, and because population cycles of Canada lynx and snowshoe hare (*Lepus americanus*) are directly related. A cooperative project began in 2003 to radio collar Canada lynx in northeastern Minnesota. Most animals have been captured during the winter months when there is snow on the ground. GPS collars have been deployed on 11 animals with other animals wearing VHF collars. Over 3,000 GPS locations document habitat use of both males and females, supplemented by over 500 VHF locations. Preliminary results from collars that have not been deployed for a year show 95% kernel home ranges of females have ranged from 20 to 40 km², while 95% kernel home ranges of males have ranged from 150 to over 400 km². Long-distance movements by several males have been documented. Adult females have remained in smaller areas while raising kittens. Kittens have survived at least 9 months. Abundance is being determined by following up on sighting reports and collecting scat and hair for DNA analysis. Persistence will be addressed through long-term monitoring and genetic analyses. Project results will allow management and recovery efforts for Canada lynx to be based on region-specific demographic and habitat use data.

Impact and Suppression Efforts for Five Prominent Invasive Plant Species in Northern Great Lakes Forests

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Several invasive plant species have emerged as potential threats to the ecological integrity of both managed and natural areas in the Great Lakes region by displacing native species and altering community dynamics. As part of the Center for Exotic Species and Ecosystem Science Center at Michigan Technological University, a number of research projects have been initiated, including risk evaluation, distribution, spread dynamics and management of several invasive plant species.

Garlic mustard (*Alliaria petiolata*) is becoming established in high-recreation use areas in the Upper Peninsula of Michigan, and appears to need aggressive pulling and herbicide application for control. Spotted knapweed (*Centaurea maculosa*) is prevalent in disturbed areas, and alters the biodiversity of dune ecosystems. The native Pennsylvania sedge (*Carex pensylvanica*) has become a serious competitor for northern hardwood tree regeneration in some stands in northern Wisconsin and parts of the Upper Peninsula of Michigan as a result of exotic earthworm densities and pressure from deer browse. Glossy buckthorn (*Rhamnus frangula*) is an aggressive invader in wetlands and woodlots across Michigan, and apparently requires aggressive cutting followed by herbicide application for control. Norway maple (*Acer platanoides*), planted widely as an ornamental, has invaded into the surrounding forest matrix. Being long-lived and shade tolerant, this species presents a unique challenge, especially in areas where large trees are a valuable aesthetic component.

There is still much to learn about the ecology of these invasive species, with preliminary research providing an important platform for designing options for managing vegetation communities for meeting landowner objectives.

Beech Bark Disease Monitoring and Impact Analysis System for Michigan

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This monitoring and impact analysis system was established to measure the condition and change of overstory vegetation due to beech bark disease and other disturbances. Beech bark disease (BBD) is a disease complex involving the exotic beech scale (*Cryptococcus fagisuga* Lind.) and at least 3 species of *Nectria* fungi affecting the American beech tree (*Fagus grandifolia* Ehrh.). BBD was first discovered in Michigan in 2000, although experts now believe it has been present for about 20 years. Beech scale is now present in 10 counties in Michigan.

The plot system was established during the summers of 2001-2003. It currently consists of 202 extensive plots (less detailed) and 62 intensive plots (more detailed subset of extensive plots) distributed throughout 29 counties in the eastern Upper Peninsula and western and northern Lower Peninsula of Michigan. The plots are distributed over a patchwork of different ownership and management regimes. Beech scale is currently in 36% of the plots. In 2004, extensive plots established in 2001 were remeasured and data was analyzed to determine the changes in overstory vegetation due to beech bark disease and other disturbances during the three years. Leaf transparency and dieback ratings increased in plots with and without beech scale between 2001 and 2004. Plots with beech scale had a higher proportion of dead beech compared to plots without beech scale in both 2001 and 2004. The proportion of dead beech increased between 2001 and 2004 in all plots showing an overall increase in beech mortality throughout Michigan's forests.

Post-Glacial Recolonization Pathways into the Great Lakes Region by the Common Gartersnake (*Thamnophis sirtalis*) Inferred from mtDNA Sequences

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Pleistocene events played an important role in the differentiation of vertebrate populations in the Great Lakes region. While several hypotheses regarding recolonization of this region have been advanced, none have been strongly supported. We generated 148 ND2 mitochondrial DNA sequences from common gartersnake (*Thamnophis sirtalis*) populations throughout the region to evaluate phylogeographic patterns and population structure and to determine whether the distribution of haplotypic variants is related to the retreat of the Wisconsinan glacier. The common gartersnake was utilized, because it was one of the primary vertebrate invaders of the region following the most recent period of glacial retreat and because it has been a model species for a variety of evolutionary, ecological, and behavioral studies over the last 50 years. Several genetically distinct evolutionary lineages were supported by both genealogical and molecular population genetic analyses. The geographic distribution of these lineages is interpreted as reflecting post-glacial recolonization dynamics during the late Pleistocene. Specifically, an older cluster of haplotypes is found primarily in the states below Lake Michigan (Illinois, Indiana, Ohio) with two more derived clusters extending from Indiana northward into the lower peninsula of Michigan and from Ohio, Indiana, and Illinois northward into Wisconsin and the upper peninsula of Michigan. These findings generally support previous hypotheses of range expansion in this region. The two more derived clusters of haplotypes also come into secondary contact in the Beaver Archipelago of northeastern Lake Michigan, which leads us to reject earlier hypotheses that this archipelago was colonized from lower peninsula populations only.

Status and Population Structure of Coaster Brook Trout at Isle Royale National Park, Michigan

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Isle Royale National Park, Michigan, is one of a handful of locations in Lake Superior that continues to support remnant coaster brook trout populations. Beginning in 1993 and continuing to the present the U.S. Fish and Wildlife Service has conducted surveys to describe the status, life history, and biological characteristics of discrete populations around the island. Information will be presented that describes population size and structure, regulations, and management actions that have been implemented. Data from tag recoveries, abundance estimates, and index station monitoring suggest that further regulatory changes may be required for long term perpetuation of these populations.

Root Symbiotic Mushrooms of Old Growth Red Pine Forests along a South Shore of Lake Superior

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Root symbiotic mushrooms fruiting in old growth red pine (*Pinus resinosa* Ait.) stands of the Huron Mountains, Marquette Co., Michigan have been systematically surveyed at seven sites in late August and September for the past nine years. Considerable annual variation in numbers and species of mushrooms occurs; amount of fruiting can often be correlated with amount of precipitation prior to surveys. Among years, a high of 56 species in 1996, and a low of 13 species in 2000 were recorded, with an average of 37 species recorded annually. A total of 100 species of red pine root symbiotic mushrooms have been recorded thus far. Due to the relatively unbroken and extensive tract of old growth forest in the Huron Mountains, some of the species that occur are not commonly found in other regions of the Lake States. Sixteen species of rare and unusual root symbiotic mushrooms have been recorded thus far.

Status and Strategies for Designing a Long-term Ecological Monitoring Program for Nine National Parks in the Great Lakes Inventory and Monitoring Network

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The Great Lakes Inventory and Monitoring Network is one of 32 networks of national parks across the United States. In 2002 the Great Lakes Network began planning a long-term ecological monitoring program for the nine National Park Service units in the upper Midwest. By December of 2005 we will complete detailed field protocols for monitoring five indicators, termed “vital signs”, of ecosystem health. We intend to implement monitoring of these five vital signs in summer 2006. The five initial protocols are: Land Use and Cover, Water Quality for Inland Lakes, Water Quality for Large Rivers, Amphibians, and Bioaccumulative Contaminants of Concern. By 2007 we expect to add Terrestrial Vegetation, Deer Browse, and Weather. Protocols for additional indicators will be developed and implemented over the ensuing years.

The design of a complex long-term monitoring program requires collaboration between land managers and scientists from a number of disciplines. In this paper we briefly summarize the status of the program and then describe a proposed sampling framework. When possible, the Network will strive for probability-based sampling that includes co-locating sample sites to increase data sharing. In some instances, however, probability-based sampling may be inappropriate or ineffective and sample site selection will be based on the strategic needs of park managers.

Effects of *Centaurea biebersteinii* on Plant and Ground Dwelling Arthropod Communities within a Lacustrine Dune System

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Open dune systems are being degraded through human development and exotic species invasions. The Grand Sable Dunes, Pictured Rocks National Lakeshore, Michigan, are protected from development but not from the spread of exotic species. The invasive exotic spotted knapweed, *Centaurea biebersteinii*, has invaded significant portions of this dune system. In 2003 we assessed the diversity of vegetation in 1m² quadrats along 500-600m transects through areas with and without spotted knapweed. In addition, pitfall traps were installed in areas with and without spotted knapweed in order to determine the diversity of ground dwelling arthropods.

Areas without spotted knapweed had higher native plant diversity than areas with spotted knapweed. These same areas without spotted knapweed had lower exotic plant diversity. Of plants occurring in the highest frequencies along transects in spotted knapweed infested areas and transects in non-spotted knapweed infested areas, four out of five native plant species occurred more often along transects in non-spotted knapweed areas than along transects in spotted knapweed areas. Insects in the families Coleoptera: Curculionidae and Hymenoptera: Formicidae were captured more often in areas with spotted knapweed. Arachnidae: Opiliones individuals and the state threatened locust species *Trimerotropis huroniana* (Orthoptera: Acrididae) were captured more often in areas without spotted knapweed. There was no significant difference for captures in areas with and without spotted knapweed for individuals in the arthropod families Arachnidae: Araneae, Coleoptera: Carabidae, and Coleoptera: Staphylinidae. Limiting the range of spotted knapweed in dune systems could maintain natural insect communities and promote greater native plant diversity.

Moose as the Boreal Hippo: Insights from Stable Isotope Analysis at Isle Royale National Park

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Body reserves accumulated during the summer may be an important factor in winter survival for herbivores in northern temperate climates. Aquatic habitats are readily used by moose (*Alces alces*) for summer foraging. However, little consideration has been given to the comparative quality of aquatic versus terrestrial forage types. Furthermore, the extent to which the summer diet of moose is derived from aquatic sources has been difficult to quantify. We compared the nutritional quality (as measured by crude protein content and C:N ratio) of summer (aquatic and terrestrial plants) and winter (terrestrial plants and lichens) moose forage types at Isle Royale National Park, Michigan. Additionally, we estimated the contribution of each forage type to the diet of moose through stable isotope analysis of hooves and forage plants. The quality of aquatic plants was significantly higher than both preferred summer and winter terrestrial plants and lichens. Mixing models incorporating stable isotope results suggest that between 14% and 37% of summer moose diet is derived from aquatic sources. We suggest that aquatic foraging by moose may be a mechanism of attaining high quality forage in an otherwise poor quality terrestrial environment. Significant isotope distinction among terrestrial and aquatic food sources further indicates that continued methodological advances in stable isotope ecology will enhance our understanding of the ecological importance of aquatic feeding to moose population dynamics.

Time Lags and Invasion Risk: Reconstructing the Invasion of Mackinac Island by Norway Maple

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Perennial, woody invaders may experience long establishment phases between widespread introduction and invasive spread, confounding risk assessment efforts. In order to investigate the risk to protected areas in the Great Lakes states posed by Norway maple (*Acer platanoides* L.), a widely planted ornamental exotic tolerant of shade, we reconstructed its invasion of Mackinac Island State Park. Every *A. platanoides* ≥ 0.5 m in height that had successfully established within the park was measured and mapped. A simple age-diameter relationship, developed from a randomly selected sub-sample, was used to assign an establishment date to each individual. Following a 34-yr establishment phase, the area occupied by ≥ 1 *A. platanoides* ha⁻¹ increased linearly at a rate of 5.6 ha yr⁻¹ for 35 yr, after which range expansion slowed. Population growth lagged behind range expansion with rapid population expansion associated with infill between parents. During the expansion phase, numerous satellite populations established, but contributed little to population expansion because of the long time required for them to become reproductive. These satellite populations will most likely accelerate population expansion and spread once they reach reproductive age. Our results suggest that shade-tolerant invaders with long generation times may undergo long establishment phases as well as periodic lags during the expansion phase. These lags may provide windows of opportunity for control, but could easily be misinterpreted as signs that the population has reached an equilibrium density or the geographic extent of its spread. Additionally, roads and trails may provide important corridors for movement of propagules.

Logging Versus Fire: How Does Disturbance Type Influence the Abundance of *Pinus strobus* Regeneration?

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Eastern white pine (*Pinus strobus*) has decreased in abundance over the past century throughout the Great Lakes Region of North America, but the relative constraints placed on recruitment under contrasting disturbance regimes are not well understood. The objectives of this study were to determine the extent to which white pine could invade areas recently disturbed by fire and logging, and assess the relative limitations placed on recruitment by seed supply, microsite habitat, and competition. We compared white pine regeneration on 61 sites disturbed by fire or logging that were adjacent to intact mature stands that provided a seed source. White pine seedling and sapling densities declined with increasing distance from a seed source, and the rate of decrease was determined by the interaction between seed supply and variation in number and quality of safe sites. For a given combination of seed source and site, white pine seedlings were three times more abundant on burned than logged sites. White pine seedlings grew into sapling more often on burned than logged site due to lower shrub cover on burned sites. At 25 years after disturbance, regeneration densities of white pine sufficient to achieve eventual future dominance occurred up to 80 m and 120 m from the edge of mature white pine stands after fire and logging respectively. To attain a similar level of white pine stocking after disturbance, three to four times as many patches of mature white pine are needed to be left after logging than after fire.

A Multidisciplinary Approach to Monitoring Ecological Effects of Lake Level Management on Voyageurs National Park

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One of most significant challenges to natural resource management in Voyageurs National Park is identifying and mitigating impacts to aquatic resources from artificial water level management on the Park's large lakes. Privately owned dams controlling the flow out of Rainy Lake and the Namakan Basin have been in place for nearly a century. Water level management has recently been changed to mimic a more natural water cycle, particularly in reducing the winter drawdown in the Namakan Basin. Voyageurs National Park and other stakeholders were mandated to monitor the effects of this new (and experimental) water management regime. This talk will highlight current and proposed monitoring of several biological indicators conducted by Park staff, in cooperation with other stakeholders and partners, including: aquatic vegetation communities, furbearer habitat and behavior, benthic invertebrate communities, harvested fish populations, mercury concentrations in game fish, and common loon nesting success.



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POSTER PRESENTATION ABSTRACTS

Dogwood Anthracnose Spreads to Parks and Game Areas in Michigan

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The objective of this study is to map the spread of Dogwood Anthracnose, a lethal disease of *Cornus florida*, in Michigan during 2004-2005. The results are compared to our 1997 study for location, incidence and impact. Fifty GPS-positioned permanent impact plots were established in natural dogwood stands in 30 counties in 1997. In 1997 three counties had diseased dogwood stands, in 2000 six counties, and in 2004 at least 11 counties. The present survey which is not yet complete has discovered spread of the disease since 1997 into the following: State Game Areas, including Allegan, Cannonsberg, Muskegon, and Yankee Springs; Metroparks, including Kensington, Lower Huron and Oakwoods; and, State Recreation Areas, including Fort Custer, Highland, and Yankee Springs. Spread of the disease through the fragmented forests of Michigan is primarily through introduction of infested ornamental plants of *C. florida* and *Cornus kousa*, including ornamental plantings around park buildings, as well as through natural spread. Surveys of Michigan nurseries reveal that hundreds of infested *C. florida* arrive from eastern and western states, yearly. The shipment and distribution of these plants are not being controlled by regulatory agencies.

Specific Growth Rate Differences between Lake Migrating and Stream Resident Brook Trout (*Salvelinus Fontinalis*) and Steelhead Trout (*Oncorhynchus Mykiss*)

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Most salmonids, including brook trout (*Salvelinus fontinalis*) and rainbow trout (*Oncorhynchus mykiss*), exhibit both anadromous (migrant) and nonanadromous (resident) forms within some populations. Although studies have found differences in juvenile growth rates and behavior attributed to these different life histories, little has been documented in the Great Lakes. We PIT tagged fish following a spatially and temporally stratified protocol in two creeks located in Pictured Rocks National Lakeshore. Each creek was equipped with PIT tag reading antennas where it entered Lake Superior. Trout were recaptured throughout the summer in the streams and fish total length (mm) and mass (g) were taken. Specific growth rates (% increase in mass/day) and condition factor were calculated for tagging cohorts of each species. Fish that moved downstream past the antenna system tended to have a higher average, though not significant, specific growth rate (.26% g/day vs .21% g/day) for all four tagging cohorts. Our findings show a trend that concurs with previous work that suggests that metabolic and feeding rates differ between juvenile salmonid life-history variants.

Developing Societal Sustainability Indicators for the Great Lakes Region

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Development of sustainability indicators that reflect environmental, economic, and societal trends continues to be a major focus of many groups, including the Developing Sustainability Committee of the Lake Superior Binational Program and the State of the Lakes Ecosystem Conference (SOLEC). Our research to determine the availability of baseline data to support proposed indicators complements efforts to refine the suites of indicators themselves. We documented trends in land use planning and acres of land protected from development within the Great Lakes basin, as well as trends in population density, economic prosperity, energy consumption, and other measures in the Lake Superior basin. GIS files of all local government entities within the Great Lakes basin were essential in obtaining basin-specific data from groups such as the Land Trust Alliance.

Findings include an increase in the number of known land trusts within the U.S. Great Lakes basin from three in 1930 to 116 in 2000. Protected acreage more than doubled between 1990 and 2000, from 177,000 to nearly 400,000. “Green” planning is clearly increasing, but consistent measures will require much more work.

Partnering with groups that already gather data will hasten the development of societal sustainability indicators. Modifying data collection methods or documentation slightly, such as by identifying the watershed, will produce more useful data for the indicators. Measuring societal indicators offers significant benefits for on-the-ground planning. However, useful spatial and temporal trends will emerge only if there is an ongoing effort to standardize information from disparate sources. Indicator descriptions are located at <http://binational.net/sogl2003/>.

Prescribed Fire Influences on Mercury Pathways in the Boundary Waters Canoe Area Wilderness, Minnesota

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Because of its persistence and wide dispersal in the environment and its ability to bioaccumulate in organisms, mercury (Hg) is a contaminant of great concern. Although scientists are beginning to understand the Hg cycle in forested systems and the important Hg species that lead to bioaccumulation in the food chain, little is known about the role of fire in the Hg cycling processes. The North Central Research Station and the Superior National Forest have started to fill these data gaps by establishing a plan to monitor mercury changes during fuel reduction efforts in northeast Minnesota. The study site is in the Boundary Waters Canoe Area Wilderness (BWCAW) in the Superior National Forest. A prescribed burning program was developed on the forest in response to a major blow-down event that occurred in July 1999. About 30,000 of the 445,000 ha in the BWCAW will be burned as strategic patches in the blow-down area over a 5-7 year period to reduce fuel loads. This will provide a rare opportunity to study mercury in a wilderness area that is dominated by lakes and wetlands. In this study soil, water, and fish chemistry information is gathered before and after burns in lakes that are both inside and outside of watersheds where prescribed burn activities are taking place. The goal of the study is to determine if there is an effect of fire on fish mercury content, and if so, to suggest mitigation strategies. The progress of the study to date will be discussed.

The Relationship Between Rainfall and Migration Rates of Stocked and Wild Brook Trout (*Salvelinus Fontinalis*) from Streams to Lake Superior in Pictured Rocks National Lakeshore

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Increased discharge often correlates with increased rates of smolt migration in Pacific (*Onchorhynchus spp.*) and Atlantic salmon (*Salmo salar*). In natural systems, stream discharge increases due to snow melt and rainfall. In this study, we investigated the potential impact of variability in rainfall on movements of brook trout from Pictured Rocks National Lakeshore tributary streams into Lake Superior. Reported rainfall (Newberry and Chatham, MI - NOAA) was assumed to be positively correlated with increased stream discharge, although the responses among streams were likely to be unequal. Wild and Tobin Harbor strain (hatchery) brook trout in the study streams were captured and individually coded passive integrated transponder (PIT) tags were implanted intraperitoneally. Migration rates were monitored with stationary Texas Instruments® Radio Frequency Identification Systems (TIRFID) at the mouth of the Hurricane River, Mosquito River, and Sevenmile Creek, which recorded the date and time of individual movement. The results of our study showed a slight relationship between rainfall events and migration of brook trout to Lake Superior. More direct and temporally continuous measurement of stream discharge would lead to a better understanding of its influence on migratory timing of brook trout.

Inventory of Inland Fishes at Sleeping Bear Dunes National Lakeshore

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The Sleeping Bear Dunes National Lakeshore (SLBE) is comprised of 71,189 acres (private lands) situated in northwest lower Michigan and contains at least 19 inland lakes that offer fisheries accessible to the public. A fish survey at Sleeping Bear Dunes National lakeshore has not been conducted since 1979. A total of 76 fish species, 10 of which are exotic, were identified in the 1979 inventory, with the greatest diversity found in the stream systems within SLBE. Represented gamefish families included: Centrarchidae, Esocidae, Ictaluridae, Percidae and Salmonidae. In an effort to supplement existing surveys and maintain current records on lake evaluations, the Grand Traverse Band Ottawa and Chippewa Indians, Natural Resources Department (GTB-NRD) performed fishery surveys on lakes within SLBE. In 2003 and 2004 we collected fish community and habitat information including presence/absence, species richness and diversity, contaminants, size and age class data, and structure and cover compositions in streams, inland lakes, and selected Lake Michigan shoreline areas of SLBE. We also conducted detection surveys for fish in the Aral Springs, wetland areas near Peterson Road and other small water bodies not considered to contain fisheries valuable to the public. Since the 1979 survey, zebra mussels (*Dreissena polymorpha*) have invaded SLBE and colonized some of the inland lakes. We also monitored for the spread of exotic species including zebra mussels, rusty crayfish, and Eurasian water milfoil.

Quantitative Assessment of Zebra Mussels (*Dreissena polymorpha*, Pallas, 1771) in the Lower St. Croix River at Native Mussels Beds

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The St. Croix National Scenic Riverway was designated the first wild and scenic river unit of the National Park System in 1968. The Riverway is considered a nationally significant resource for its richness and abundance of freshwater mussels (about 40 species, the greatest in the Upper Mississippi watershed) and is recognized for its outstanding recreational and biological assets. The diversity of unionids within the Riverway is well documented and many threats to their diversity have been identified. This faunal group will be severely impacted by zebra mussel infestations and from other exotic invasions. Freshwater mollusks are a keystone faunal group of freshwater systems and their potential loss is unacceptable.

In order to understand the invasion of zebra mussels into the Riverway, measurements of density were taken within the known infestation zone (the last 21 miles of the river). Anecdotal evidence from the upper Mississippi River suggests zebra mussel colonization predominates on native mussel beds, especially where substrates (e.g., sand, silt, etc.) are less favorable for recruitment. Therefore, sample locations were chosen based on native mussel bed survey work previously conducted by the second author. Six locations were identified from Stillwater, MN to Prescott, WI, reflecting the range of habitats and hydrology found in the infestation zone. Thirty 1/8-meter quadrat samples were collected by divers at each of the locations. These samples were processed off-site, frozen and examined under magnification. Information from the project will help managers determine the spread and intensity of the invasion.

The poster will demonstrate the methods established to determine zebra mussel densities on the lower river, and present results of not only this invasive, but of Asian clams and snails found during the sampling events. It will also highlight management decisions resulting from this information.

Hematological Assessment of Immune Response and Healing of Sea Lamprey (*Petromyzon marinus*) Wounds on Lake Trout (*Salvelinus namaycush*)

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The Great Lakes Fishery Commission's 2001 "Vision Statement on Integrated Management of Sea Lamprey" includes a major goal that I address in this study: reducing adverse economic impacts to levels that will maximize the benefits of sea lamprey control and fishery management, resulting in a balance between resource losses and economic expenditure (GLFC 2001). The dilemma is placing an economic value on the potentially "saved" fish. One way of determining saved fish is by evaluating the healing that takes place after a lamprey attack. Similarly, numbers of wounded prey fish (wounds per 100 fish) are used to estimate lamprey abundance in the Great Lakes.

During the spring and fall of 2004, we used hematological methods to assess immune response in lake trout (*Salvelinus namaycush*) after sea lamprey (*Petromyzon marinus*) wounding. The study area was in the northern region of Lake Huron from Alpena, MI to Drummond Island, MI. Both wounded and unwounded lake trout were sampled to determine if there was a detectible difference in immune status as indicated by differential leukocyte counts: hematocrit and leukocrit. The data show that there was no difference in leukocrit and lymphocyte counts. There was a significant difference ($p < 0.001$) in hematocrit, thrombocyte, granulocyte, and total leukocyte counts between the control groups and the groups of wounded fish captured in both gill and trap nets. There was no difference in leukocrit percentage ($p = 0.178$) and lymphocyte counts ($p = 0.065$) between groups. Photographs of the wounds were taken at the time of initial capture and lake trout were tagged with a uniquely numbered floy tags for later recapture and healing assessment. The data collection is ongoing and is expected to conclude during July 2005.

Invertebrate Biodiversity in Northern Hardwood Ecosystems under Varying Disturbance Regimes

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From 2003-2005 we are investigating ground-dwelling arthropod occurrence in Michigan northern hardwood forests with and without beech bark disease (BBD= beech scale + fungi). Differences are being studied by: 1) Forest type (maple-beech vs. oak-beech), 2) Presence/absence of mechanical thinning, and 3) Downed woody debris (DWD) quantity and decay stage. Specific research questions being asked include: (1) What is the relationship between forest type and ground-dwelling arthropod diversity? (2) What is the effect of BBD on biodiversity of ground-dwelling arthropods? (3) What is the effect of mechanical thinning on biodiversity of ground-dwelling arthropods? (4) What is the relationship between downed wood and ground-dwelling arthropod diversity? We are collecting ground-dwelling arthropods using unbaited pitfall traps in 48 northern hardwood stands in Michigan. Ground beetles (Coleoptera: Carabidae), camel crickets (Orthoptera: Gryllacrididae) and sowbugs (Crustacea: Isopoda) are identified to species. Spiders (Araneae) are identified to the family level. Carabid beetles were 1.5 times more abundant in thinned stands versus unthinned stands. Carabid species' occurrence in treatment and forest types is variable at the species level. Carabid species diversity is higher in oak-beech forests, unthinned stands, and stands without beech scale compared to maple-beech forests, thinned stands, and stands with beech scale present, respectively. Carabid abundance is highest in areas with very low DWD although carabid species diversity is highest in DWD piles with high volume and advanced decay stages. The goal of this research is to help explain the complex relationships and interactions between ground-dwelling arthropods, forest stand characteristics, and disturbances in Michigan's northern hardwood forests.

Forest Management, Deer Herbivory, and Exotic Earthworm Activity Contribute to Pennsylvania Sedge Cover in Wisconsin's Northern Hardwood Forests

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Natural resource professionals in northern Wisconsin have observed dramatic increases in the abundance of Pennsylvania sedge (*Carex pensylvanica* Lam.) in some hardwood forests. This native species displays invasive behaviors in these stands, forming dense mats that limit tree regeneration. We examined the relationship between management intensity, deer density, exotic earthworm density, and Pennsylvania sedge cover in 18 hardwood forests. We selected stands based on a gradient of management history (even-aged, uneven-aged, and unharvested second growth) and deer density (moderate density, 10 to 20 deer/km², or high density, >20 deer/km²).

Even-aged stands with high deer densities were associated with higher sedge cover than unharvested stands and even-aged stands with moderate deer densities, and there was a nonsignificant trend that suggested higher cover in uneven-aged stands. Earthworm density had a positive relationship with sedge cover in even-aged stands with high deer densities, but no significant relationship in other management and deer density combinations. Pennsylvania sedge cover was also negatively correlated with the density of advanced regeneration and seedling diversity. These preliminary findings indicate changes in disturbance regimes and soil processes have the potential to alter the dynamics of the understory community, and have a direct relationship with the formation of Pennsylvania sedge mats in Wisconsin's forests.

A Predictive Model for Exotic Plant Species for the Great Lakes Network of the U.S. National Park Service

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As part of the nationwide Inventory and Monitoring initiative being implemented by the National Park Service (NPS), we are developing predictive models for exotic plant species in the nine national parks within the Great Lakes Network. Exotic plants are one of the selected key Vital Signs which will be monitored annually by the NPS, and will serve as early warning indices of change.

For each site in the Great Lakes Network, we are producing Geographic Information System (GIS) layers of the distribution of spotted knapweed (*Centaurea biebersteinii*), purple loosestrife (*Lythrum salicaria*), exotic honeysuckles (*Lonicera* spp.), baby's breath (*Gypsophila paniculata*), reeds (*Phragmites* spp.), garlic mustard (*Alliaria petiolata*), multiflora rose (*Rosa multiflora*), common buckthorn (*Rhamnus cathartica*), leafy spurge (*Euphorbia esula*) and glossy buckthorn (*Frangula alnus*) based on existing data collected in recent years by the National Park Service. Multi-criteria risk models will be produced that predict the risk of introduction, establishment and spread of these species where they present a risk in coastal dunes, marsh/bog, woodland, and grassland habitats. The predictive models will be developed using existing park GIS layers including topography, soils, vegetation, transportation, cultural features (e.g. campsites), hydrography, wetlands, and proximity to and extent of known infestations, as well as site preferences of each species derived from the available literature.

These models will be validated using historical data from the parks, current distribution within the parks, field observations of high risk areas, and information from other infested areas. Models will be refined based on the validation stage and peer review.

Cattail (*Typha* spp.) Invasions in Great Lakes Parks: Why Is It Happening and Can We Control It?

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Two species of cattail (*Typha* spp.), one native and one exotic, *latifolia* L. and *Typha angustifolia* L. These species and their putative hybrids also occur throughout all of the Great Lakes National Parks (except ISRO). The interspecific hybrids are difficult to distinguish from the parental species because they form morphologically complex associations. *Typha* complexes are aggressive invaders of shallow bays and quickly out-compete other aquatic plants, essentially creating monocultures of low biological diversity. Cattails are especially adapted to invading disturbed systems such as those created by varying water levels or subject to external nutrient inputs. This poster will give an overview of the variation in *Typha* species/hybrid ecology and invasion ability in the region. We will also outline different management strategies that could be employed in National Parks to manage these invasions.



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